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Communication from J. Herbert Shedd · 1873

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COMMUNICATION

FROM

J. HERBERT SHEDD,

IN REVIEW OF THE COMMUNICATION FROM GEO. H. CORLISS

UPON THE

PUMPING ENGINE

AT HOPE STATION.

(Presented to the Board of Aldermen, December 4, 1873.)

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REPORT.

PROVIDENCE, R. I., Dec. 3, 1873.

TO THE HONORABLE THE BOARD OF ALDERMEN:

I respectfully ask permission to review certain statements made to you by Mr. George H. Corliss, in reference to my report to the Water Commissioners, on the subject of pumping engines.

Mr. Corliss says: "for the work at Pettaconset station, the engine *would be* like the [his] mill engines." If so, it would be so unlike the Hope engine as to form another new experiment in pumping water.

He says the exposure of steam to cooling influences "amounts by actual computation to less than one half of what it is in a Cornish engine of the same pumping capacity." A certain thickness of the inside of a cylinder is warmed every time steam is received, and cooled every time it is discharged. This thickness, and the amount of heat lost, depends on the difference of temperature—the specific heat of the material—its conducting power, and the time of exposure. The loss resulting from this process is very great. It has been found in a practical example of an engine burning not more than 3 lbs. of coal per horse power per hour, having a piston speed of 500 feet per minute and cut-off at one-tenth the stroke, that it actually used about twice as much steam as it would but for cylinder condensation. As all steam cylinders are now made of cast iron, we may, for comparison, ignore the specific heat and conducting power, and confine ourselves to the difference of temperature and time of exposure. I do not give it as critically accurate, but a simple and fair comparison, as a whole, may be made by taking the product of the difference of temperature, the area and the time.

In Mr. Corliss's engine there are five cylinders of twenty inches diameter and two and a half feet stroke. The maximum requirement of the engine, according to the contract, is to deliver with ease five million gallons of water in twenty-four hours, to a height of one hundred and twenty feet. For this purpose the contractor has stated that the engine will make 25 revolutions per minute. As there are five cylinders, each double-acting, there will be 250 single strokes per minute. The time required for each stroke will be 1.20 seconds. The area of the head of the cylinder (2.18 feet), one side of the piston (2.18 feet), and the side of the cylinder (13.09 feet), is 17.45 feet. This is to be warmed and cooled 250 times per minute, equal to 4,362.5 square feet warmed and cooled once. With the initial pressure 75 lbs., equal to 307° temperature—8 expansions, terminal pressure 7.8 lbs., equal to 182° temperature, and a condenser temperature of 100°, we call the mean difference of temperature 144½°. 4,362.5 x144½, equal to 630,380. The exposure is during 1.20 seconds of time, 630,380x1.2, equal to 756,456, which is a number for comparison.

For a Cornish engine of equal pumping capacity we have one cylinder of 67½ inches diameter, 9 feet stroke, and making 9 strokes per minute. The steam stroke is made in about 1.67 seconds. The area of the head of the cylinder (24.84 feet,) one side of the piston (24.84 feet,) and the side of the cylinder (161.88 feet, with 2 inches clearance,) is 211.56 feet. This is to be warmed and cooled 9 times per minute, equal to 1,904.04 square feet warmed and cooled once. With the initial pressure 51 lbs., equal to 282° temperature—8 expansions, terminal pressure 5.36 lbs., equal to 165° temperature, terminal cushion pressure 34 lbs., equal to 258° temperature, condenser temperature 100°, we call the mean difference of temperature 90⅓°. The exposure is for 1.67 seconds. 1,904.04x90⅓, equal to 172,000 and multiplied by 1.67, equal to 287,240, for comparison.

The cooling influences by this comparison are as 100 in Mr. Corliss's engine, to 38 in a Cornish engine, or more than 2½ times as large.

The product of the length of steam packing, which would allow leakage, multiplied by the time of exposure to steam pressure, is about 6 times as great in the Hope engine as in a Cornish engine. The net pressure of steam to cause leakage is 50 per cent. greater.

We have considered the internal, which are by far the most important cooling influences, and if the matter were pursued to the end, the results would be in the same direction.

In my communication to the water commissioners I compared the cooling influences in Mr. Corliss's engine with those in the present Pettaconset engine, and a similar comparison was made in regard to areas subject to friction, but Mr. Corliss chose to use them as being made with a Cornish engine; hence the above comparison to show that the statement, in regard to cooling influences, is equally true when compared with that engine.

The areas of pistons and plungers subject to friction are about 25 per cent. greater in Mr. Corliss's engine than in a Cornish engine of the same pumping capacity, and the other areas are much more in excess.

We estimate the ratios between the Hope engine, and a Cornish engine, in several important particulars, as follows:

	Corliss.		Cornish.
The relative piston speeds are as	100	to	260
do. plunger do. as	100	to	86
do. internal cooling influences as	100	to	38
do. loss by leakage of steam as	100	to	17
do. pressure to cause leakage as	100	to	64

These comparisons are uniformly in favor of the Cornish engine.

Mr. Corliss seems to confound connections with connecting rods, which I regard as a misuse of terms, as the best authorities define connections to be points of junction and joints. The most careless reader could hardly fail to understand my statement, and it *is true* that there are nineteen loose and unadjustable connections between the steam and water pistons on his engine. There are no loose connections whatever between the steam and water, on the Pettaconset engine, and there are no *such* connections on a Cornish engine, where the strains are all one way and the thumps resulting from reversible strains do not occur.

There is nothing in the action of the engine at Pettaconset which is injuriously affected by the air chamber, but I had supposed that the action of the Hope engine could not be made satisfactory when the air chambers were on.

A false impression is given when Mr. Corliss, after referring to the valves of the Louisville engine, says: "The specifications for the Cornish pumping engine for Providence water works call for twenty-one of these valves. The twenty-one valves do similar work to the two valves at Louisville. If Mr. Corliss's valves were required to pass the sand pumped by the Louisville engine, the *seats* and valves would require large expenditure. The chief engineer of the Louisville water company, in his report under date of January 1, 1870, after stating that a record is kept of every trifling accident, and all repairs, says: "An examination of this record will demonstrate the fact that not any of the annual repairs are properly chargeable to *kind* or *type* of engine."

The coal vaults at Hope station are designed to hold about a year's supply for an engine doing a duty of 40,000,000, while delivering to the high service, the quantity of water estimated to be required when a supply of 12,000,000 gallons is delivered to the whole city, that being the quantity on which the entire works are based. The total actual cost of the vaults has been $7,390.27. An engineer who should build permanent coal vaults suited only to the requirements of the service two months after the water is let on, would probably find but a limited demand for his services. Every city in the country of which I have information, excepting, perhaps, the city of Washington, has proved that the first estimates of the probable demand for water have been under the actual requirements; and in many cases great loss of money has resulted from the failure to build adequate works in the first instance. In 1870, engines were put in operation to supply the high service of Boston, and this year the city engineer reported that "the existing machinery is unable to perform the duty required of it," and at the request of the water board he reported on the means of securing an adequate supply of water.

Under the maximum requirement of the contract, the Hope engine will need to exert about 105 effective horse power.

Mr. Corliss's declaration that "any calculation based upon a better result" than forty millions duty in Cornish engines, "is based upon the prospective success of the schemes of *amateurs*, and they are simply the result of the investigations of theory," may be sufficiently answered by the following table, taken from Hughes on water works, reduced to the standard of 100 lbs. of coal. The figures were taken by him from Lean's reports; Captain Lean being a disinterested engineer, employed by the various proprietors to report the facts in relation to their engines, with a view to their improvement. That the improvement was made is strikingly illustrated by the table:

Year.	No. of engines.	Average duty.	Average duty of the best engines.	Year.	No. of engines.	Average duty.	Average duty of the best engines.
1812	21	20.53		1828	57	39.37	81.61
1813	29	20.71	28.04	1829	53	42.29	81.79
1814	32	21.88	34.03	1830	56	45.98	82.86
1815	35	21.79	30.45	1831	58	46.07	75.54
1816	35	24.46	34.46	1832	59	45.90	90.26
1817	35	28.13	44.20	1833	56	49.46	89.55
1818	36	26.96	41.79	1834	52	50.80	96.52
1819	40	27.95	42.50	1835	51	50.80	97.41
1820	46	30.45	43.84	1836	61	49.46	90.71
1821	45	30.00	45.45	1837	58	49.91	92.68
1822	52	30.71	45.18	1838	61	51.79	89.46
1823	52	30.00	44.64	1839	52	58.39	82.68
1824	49	30.09	46.25	1840	54	57.41	86.79
1825	56	34.02	48.21	1841	56	58.12	108.28
1826	51	32.41	48.04	1842	49	57.14	114.20
1827	51	34.11	63.39	1843	36	63.75	102.14

The following table, "from Browne's reports for the year 1855," is also taken from Hughes' treatise,—the duty being reduced to 100 pounds of coal:

1855.	*No. of Engines Reported.*	*Average Duty.*	*Duty of Best.*
January	15	62.41	89.91
February	15	62.59	87.41
March	15	61.34	86.96
April	15	61.07	90.45
May	15	61.52	89.55
June	15	61.96	87.50
July	15	61.70	88.48
August	15	61.96	89.37
September	14	62.23	90.54
October	13	63.93	89.64
November	13	63.66	88.21
December	12	62.68	89.29
Average		62.23	88.93

The number of engines reported in these tables sufficiently shows that the duty given is not exceptional. I stated in my communication to the water commissioners that poor results had been obtained in some of the Cornish engines in this country, and that it was believed the principal reasons for such results were understood and could be avoided. I was well acquainted with the duty obtained at Louisville and Cleveland, and those engines were in my mind when the above statement was made.

"No Cornish engineer will say that because a Cornish engine *is* a Cornish engine, it will pump a great deal of water by the consumption of a comparatively small quantity of coal. Its correct design and construction [enable the coal to] do the superior duty."

It is true that the duty of mining Cornish engines has fallen off in the last thirty years, but it will not be claimed that steam or water act differently now, or that engine builders are not able to do as good work as formerly. What has been done may be done again, and the reasons for this falling off, must be looked for elsewhere. I will give a few of them:

1. A poorer quality of fuel is used. The high duty was obtained from the best Welsh coal, but lately the English engineers have been practicing what American steam users are learning to do,—they buy cheap coal because they find that for the same *money* they can pump more water than with good coal, though of course for the same *weight* the duty is less. The *duty* by *weight* has little value except for comparison with other engines.

2. The lodes are worked diagonally, which causes much more friction in the pit-work.

3. The increase of the depth of the mines, and running the pump rods on inclined shafts, varying at different stages of the depth, has made it impracticable to work the steam so expansively as formerly, on account of repeated breakages in the ponderous pit-work; so that it was shown by experience that a less expansion and a more gradual starting of the machinery, though giving a lower duty, was nevertheless cheaper and safer in the end for such work.

4. Some of the best engines are not reported.

5. When "mines were held by men who intended to work them, economy of fuel was carefully attended to." "Now, however, that so many mining operations are undertaken for the purpose of speculating in shares, the performance of the engines is regarded as a matter of secondary importance."

I do not know on what Mr. Corliss bases his "deliberate judgment," that "the experience of cities, in trying experiments with the Cornish engine, has involved more disappointments and loss of money than any and all other plans that have ever been tried." The *facts*, as far as I know them, are overwhelmingly against him

I did not voluntarily enter into this controversy, and I am sorry for the course it has taken; but, whatever the provocation to special pleading, I have endeavored to state the case fairly. Every point in this communication, and in that to the water commissioners, has been carefully considered, and cannot, I believe, be honestly controverted.

All which is submitted with great respect,

J. HERBERT SHEDD.

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